M.O. 501 AIR MINISTRY

METEOROLOGICAL OFFICE

THE METEOROLOGICAL MAGAZINE

VOL. 77. No. 907. JANUARY, 1948

THE MEETINGS OF THE INTERNATIONAL METEOROLOGICAL ORGANIZATION IN TORONTO AND WASHINGTON

AUGUST, SEPTEMBER, OCTOBER 1947

The meetings of the International Meteorological Organization (I.M.O.) which were held in Toronto and Washington from the beginning of August to mid October 1947, were of unusual interest, not only on account of the results achieved but also because of some of the precedents that were created. It was the first time in its 75-year history that any of the constituent bodies of the I.M.O. had met in the New World, and it was also the first occasion that all ten of the Technical Commissions had met together at the same time.

During the war the activities of the Organization were seriously curtailed, but as soon as possible after the return of peace steps were taken to set its machinery in motion once again. An extraordinary Conference of Directors was held in London in February 1946, during which new members of the International Meteorological Committee were elected and the Technical and Regional Commissions reconstituted. This Conference thus cleared the way for a resumption of the international procedures in operation before the war and for the world-wide introduction of improvements in the field of scientific meteorology made by certain countries during the war.

The objects of the meetings at Toronto and Washington were therefore to review and consolidate the progress made since the London Conference, to make plans for the future and to consider the structure of the I.M.O. and its relation to other international associations.

The meetings of the ten technical commissions were held in Toronto during August and the first two weeks of September, and were attended by 179 delegates from 44 countries. The meetings took place in the buildings of the University. The Conference of Directors under the chairmanship of Sir Nelson Johnson, President of the International Meteorological Organization, opened in Washington on September 22 and terminated in mid October.

It is the function of the Technical Commissions to consider their respective subjects and to make recommendations on them for consideration by the Conference of Directors. On this occasion over 400 resolutions were submitted

by the Technical Commissions to the Conference of Directors. It is, therefore, logical to consider first the work of the commissions by giving a summary of the activities of each one written by the United Kingdom delegates attending its meetings.

Aeronautical Commission (President, Mr. A. H. Nagle, Eire; United Kingdom delegate, Mr. J. Durward).—This Commission, whose meetings extended over three weeks, prepared, as its most important task, a common text for the International Civil Aviation Organization (I.C.A.O.) and I.M.O. regulations for the provision of meteorological facilities to international aviation. Taking as a basis the " Recommendations for Standards, Practices and Procedures " produced by the Meteorological Division of I.C.A.O. the Commission agreed the changes which would be necessary to make the text of that document suitable for the I.M.O. publication " Règlement général pour la protection météorologique de l'aéronautique ". The text so amended was submitted to the Conference of Directors of the I.M.O. and to the Council of I.C.A.O. for approval.

There was a very detailed discussion on the question of codes for use in the transmission of terminal and route forecasts to ground stations and aircraft and of weather reports to and from aircraft. The agreed codes were later confirmed by the Commission for Synoptic Weather Information of the I.M.O. and by the Meteorological Division of I.C.A.O. at a special meeting held in Montreal on September 17.

Other matters upon which resolutions were prepared by the Commission were climatological statistics for aeronautical purposes, the qualifications necessary to be held by the meteorological staff engaged in providing the weather service for aviation, the exchange of publications on " pressure-pattern flying ", and methods of constructing upper-level charts.

Commission for Maritime Meteorology (President, Cdr. C. E. N. Frankcom, R.N.R.; Other United Kingdom delegates, Inst. Capt. J. Fleming, R.N., Inst. Cdr. Suthons, R.N., Secretary).—In considering the first visit of this Commission to the American continent it is of interest to note that it was an officer of the U.S. Navy, M. F. Maury, who was instrumental in convening in 1854 the first international meteorological conference and who was responsible for the commencement of organised meteorological work at sea.

Probably the most important work of the Commission was the creation of a world-wide scheme for improving the network of meteorological reports from ships in every ocean. For these reports meteorologists are largely dependent upon the goodwill of voluntary observers in the merchant ships of all nations. One difficulty in connexion with this problem is that, if all the ships of the world sent in messages at each international hour (0000, 0600, 1200 and 1800 G.M.T.) there would still be large gaps in the marine network because ships tend to keep to fixed tracks. There are also serious communication problems to be considered as many ships have limited radio facilities. A number of resolutions were passed whereby maritime countries are encouraged to recruit ships to send in reports, and the oceans have been divided into agreed areas from which ships make their weather messages to selected meteorological centres. In return for these weather messages it is the duty of the Meteorological Service concerned to issue adequate weather information to the shipping in that area.

Further resolutions on this problem proposed the establishment of meteorological liaison officers to keep contact with merchant shipping in the major ports of the world. To reduce the gaps in the marine network, the Commission recommended the establishment of automatic weather stations on islands and the detection of distant storms by radio means, by microseismic observations and by aircraft reconnaissance. A scheme to provide for the co-operation of whaling vessels in the Antarctic was also put forward.

In co-operation with other Commissions, the Commission made recommendations on methods of obtaining improved accuracy in reports from the sea, and also drew up proposals for an international meteorological publication for the use of seamen. As a result of research carried out during the war by U.S. and British naval experts, considerable interest has been displayed in wave measurement at sea and a new technique has been evolved. The Commission has recommended that, in future, ships shall be requested to report the direction, period and height of waves at sea. It is considered that the reports thus received will not only enable forecasts to be made of wave conditions in distant areas but will be of considerable scientific value. In many parts of the world (e.g. the exposed shores of Portugal, Morocco and the Azores) wave forecasts are of considerable commercial importance. A knowledge of waves is also vital for aircraft operation and is of interest to ship designers. The Commission drew up a simple code for reporting ice at sea and set up a special Committee of experts to revise the present international ice nomenclature, which is somewhat out of date. Recommendations were also made concerning the treatment of marine climatological data.

Commission for Synoptic Weather Information (President, Mr. E. Gold; other United Kingdom delegates, Mr. E. G. Bilham, Inst. Capt. J. Fleming, R.N.).—The Toronto meeting of the Commission for Synoptic Weather Information (C.S.W.I.) was a momentous one in many ways. To appreciate its special character it is necessary to recapitulate briefly the events of the previous two years.

At the beginning of the war the Copenhagen (1929) code for the international exchange of weather reports was in universal use, and it fulfilled the requirements then existing. During the war, however, the growing needs for increased precision led the allied nations to agree upon certain modifications and additions. In particular it was found necessary to use two code figures instead of one for visibility and height of cloud. Extensive changes were also made in the codes for reporting upper winds, temperatures and humidities, and in addition, entirely new codes were introduced for the exchange of analyses, reports from aircraft, sferic reports and reports to aircraft in flight. The code situation at the end of the war was therefore exceedingly complex. At the Extraordinary Conference of Directors held in London in February–March 1946, the I.M.O. provisionally approved a number of the war-time codes, and decided that the C.S.W.I. should meet at an early date to consider the many urgent problems awaiting solution. The C.S.W.I. accordingly met in Paris, in June 1946, faced with the immense task of re-examining practically all the existing weather codes and specifications and recommending new codes for universal adoption; the report of the Paris meeting (I.M.O. Publ. No. 54) runs to nearly 500 closely printed pages. Most of the 56 resolutions were approved at a meeting of the International Meteorological Committee held immediately afterwards.

It was reasonable to suppose that this meeting would have resolved most of the difficulties, but the new Paris codes did not, unfortunately, meet with unqualified approval, and it became evident that discussions would have to be re-opened at the Toronto meeting, which had been planned for August-September 1947.

The meeting was held in the Economics Building of the University from August 25 to September 13. The discussions were long and arduous, but it is gratifying to record that unanimous agreement was finally reached on the question of a universal code for surface reports, the main subject of contention. The new code retains the more important features agreed at Paris (two figures for visibility, cloud height and wind speed) while at the same time meeting the wishes of those services which do not require reports of barometric tendency in an obligatory group.

Other important changes agreed at Toronto were a new world-wide system of five-figure index numbers of stations, the specification of cloud amount by eighths instead of by tenths, and the specification of surface wind direction by units of ten degrees (scale 01–36) instead of by points (scale 01–32). In a short note it is impossible to list all the subjects discussed, but reference may be made to papers on the synoptic applications of upper air data and sferic observations by Dr. R. C. Sutcliffe and Mr. C. K. M. Douglas respectively, which provided pleasant scientific relief from the discussion on codes and specifications.

Commission for Instruments and Methods of Observation (President, Dr. J. Patterson, Canada; United Kingdom delegate, Dr. F. J. Scrase).—C.I.M.O., to give it its abbreviated name, is a new Commission instituted by the Conference of Directors of the International Meteorological Organization which was held in London in 1946. The first meeting of the Commission took place in Toronto on August 4 to 16, 1947, under the presidency of Dr. J. Patterson, formerly Controller of the Canadian Meteorological Service. As the Commission was starting from scratch the President had drawn up a formidable agenda of some 120 items and sub-items with a view to surveying the whole field of meteorological instruments and methods. Eight temporary sub-commissions were formed to consider different sections of the field and to discuss the more important items in detail.

The discussions on the various instruments and methods usually turned on questions of standardization. The general feeling about this was that, although a considerable degree of standardization of meteorological instruments is desirable, to attempt to standardise the design of relatively new equipment, such as radio-sondes, would tend to discourage further development. It was, however, agreed that intercomparison of different types is necessary, and to facilitate this in the case of radio-sondes a recommendation was made for the development of a simple reference instrument, preferably employing the Olland principle, which would not need elaborate ground equipment and which could therefore be readily used as a standard for comparison by any country.

In barometry it was suggested that a conventional standard of gravity, not subject to revision, should be used and that uniformity of practice between meteorologists and physicists should be the prime consideration in adopting a standard value. A number of recommendations were made on the design

of fixed cistern barometers and on the method of reduction of pressure to standard levels. Problems of visibility measurement were considered and some changes in international practice were recommended. The Commission was of the opinion that the estimation of visibility in the day-time at land stations is better done by the simple visual method than by means of a visibility meter. Other items discussed included the standardization of thermometers and of psychrometric methods. The special needs of aviation both in regard to the measurement of wind and gustiness and to the measurement of cloud height were considered.

It was hardly to be expected that the Commission would, at its first meeting, be able to provide all the answers to the many problems which it reviewed, but a good start was made on the more important items, and a number of resolutions were drafted for submission to the Conference of Directors at Washington in September. In order to facilitate the continuation of work on outstanding problems six permanent sub-commissions were formed and the following Presidents chosen:—

Actinometry:	Dr. A. Ångström, Sweden.
Atmospheric optics:	Mr. W. E. K. Middleton, Canada.
Barometry:	Dr. K. Langlo, Norway.
Experimental aerology:	Dr. J. Lugeon, Switzerland
Guide to international meteorological instrument and observing practice:	Dr. F. J. Scrase, United Kingdom.
Station instrumentation and exposure:	Dr. C. F. Brooks, United States.

At the end of the meeting in Toronto, Dr. Patterson was re-elected President of C.I.M.O. and M. E. Papillon was elected Vice-President.

Aerological Commission (President, Dr. S. Petterssen, Norway; United Kingdom delegates, Dr. R. C. Sutcliffe, Secretary, Prof. P. A. Sheppard).—Aerology had a definite meaning in the days when observations in the free atmosphere were few and hard to make, but to-day the methods of observation have been taken over by the instrument specialists and the discussion and interpretation of the results forms the normal field of activity of the meteorological physicist or weather forecaster.

Thus while the Aerological Commission surveyed, during its meetings, the instrumental, observational and operational aspects of world aerology it decided to leave the final consideration of these matters to the appropriate Commissions and to devote the major part of its activity to the scientific and technical use of the collected upper air data.

Some of the matters considered by the Commission were:—

(1) Definitions and specifications of aerological constants and parameters.

(2) Exchange of aerological analyses between neighbouring areas of the world.

(3) Development of a precision radio-sonde.

(4) Value of aircraft reconnaissance flights in obtaining upper air data.

(5) Arrangement of "International aerological days".

(6) Use of "swarm" radio-sonde ascents in special weather situations.

(7) Frequency and times of routine upper air ascents.

(8) Use of atmospherics-location (sferics) and radar in aerological analysis.

(9) Use of rockets for upper air sounding.

(10) Routine upper air observations on ocean weather ships.

Special mention should be made of the brave attack referred to under (1) above on the problem of the definitions and numerical values of certain physical functions and numerical values used in meteorology. One member of the Commission claimed to have come with a determination to take home a definition of " front ". It is believed that he failed in that object but found he had obtained instead a new definition of relative humidity from which he may have realised the amount of work still ahead.

A sub-commission on aerological diagrams gave international blessing to many such forms of diagrams, and its meetings proved of great educational value.

On the question of the best technique for synoptic representation of the three-dimensional atmosphere rapid agreement was reached on the merits of standard isobaric surfaces. The use of standard pressure levels instead of standard heights has thus achieved international recognition 30 years after its recommendation by V. Bjerknes.

Special lectures and discussions were held at which dynamical theories and methods were the main topic, with much reference to vorticity, divergence, dynamic instability and the like, and relatively little to air masses or the polar front.

(*To be continued.*)

NOTES ON THE I.C.A.N. ALTIMETER AND HEIGHT AND AIR SPEED COMPUTOR

BY G. A. BULL, B.SC.

Part I

Altimeters and their standard atmospheres.—The pressure type of altimeter as distinguished from the radio altimeter, is an aneroid barometer. Changes in the pressure of the air surrounding the aneroid capsule are indicated on a dial in terms of height. An arbitrary relation connecting pressure changes with height changes has to be used for graduating the dial. It is customary to express this relation in terms of temperature as a function of pressure in a theoretical atmosphere which is called the standard atmosphere for the kind of altimeter under consideration. Such theoretical atmospheres seem first to have been used by astronomers in connexion with atmospheric refraction.

An altimeter reads correctly, apart from purely index or instrumental errors, in the standard atmosphere appropriate to it. In any other atmosphere it can only be correct at points such that the harmonic mean temperature between aircraft and ground equals the harmonic mean temperature in the standard atmosphere between the pressures equal to those in the actual one on the capsule and ground.

For many years the standard atmosphere used for altimeters was the very simple one defined by a constant temperature of 50° F. (10° C.). Such an

altimeter is bound to have very large errors at great heights because of the high temperature of its standard atmosphere.

For at least the last ten years an atmosphere designed by the International Committee for Air Navigation (I.C.A.N.) has been used generally in altimeter construction though instruments working on the 50° F. atmosphere still exist on light aircraft. These new altimeters were made so sensitive to small pressure changes that a change of height of 10 ft. can be read while improved arrangements were made for setting the zero of pressure and height on the altimeter.

The marks of altimeter used in the R.A.F. constructed to the I.C.A.N. atmosphere are Nos. XIV, XVI, and XVII.

This note deals with the altimeter based on the I.C.A.N. standard atmosphere and its possible errors. The computer used for rapidly obtaining a more nearly correct value of height will be discussed in Part II.

I.C.A.N. standard atmosphere.—The I.C.A.N. standard atmosphere is defined as having a temperature of 15° C. (59° F.) at a pressure of 1013·2 mb., a temperature lapse rate of 1·98° C./1,000 ft. (6·5° C./Km.) up to a pressure of 226 mb., and at pressures lower than 226 mb. a constant temperature of −56·5° C. The acceleration due to gravity, g, is taken to be constant at 980·62 cm./sec./sec. and the value of R, the gas constant for air, to be 2,870,800 C.G.S. units.

From this definition it follows that pressure and height are connected by the formulae,

$$P = 1013{\cdot}2\left(1 - \frac{1{\cdot}98\,H}{288}\right)^{5{\cdot}256} \text{ from } P = 1013{\cdot}2 \text{ to } 226 \text{ mb.} \qquad \ldots (1)$$

$$\text{and } H = 36{\cdot}09 + 47{\cdot}9 \log_{10}\left(\frac{226}{P}\right) \text{ at lower pressures} \qquad \ldots (2)$$

where P is the pressure in mb. and H is the height in thousands of feet above the level at which pressure is 1013·2 mb.

Tables for finding height from pressure in the I.C.A.N. atmosphere or conversely have been published by the National Physical Laboratory and in the Air Ministry Manual of Instruments. The most detailed table, however, is contained in Meteorological Office *Synoptic Divisions Technical Memorandum* No. 31 in which the height is given for every millibar from 1050 to 100 mb.

A brief table for ready reference in connexion with later sections of this note is given in Table I.

U.S.A. standard atmosphere.—In the United States a slightly different standard atmosphere is used.

According to Berry, Bollay and Beer's "Handbook of Meteorology", it differs in the following respects:—

Temperature		15° C. at 1013·25 mb.
Tropopause	pressure	234 mb.
	temperature	−55° C.
	height	35,332 ft.
Value of g		980·665 cm./sec./sec.

The difference between the two atmospheres is negligible, as Table II shows.

TABLE I—I.C.A.N. ATMOSPHERE

Height	Temperature	Pressure
ft.	° C.	mb.
−1,000	17	1050·3
0	15	1013·2
1,000	13	977·3
2,000	11	942·1
5,000	5·1	843·1
10,000	− 4·8	696·9
15,000	−14·7	571·7
20,000	−24·6	465·4
25,000	−34·5	375·8
30,000	−44·4	300·8
35,000	−54·3	238·2
40,000	−56·5	187·4
45,000	−56·5	147·3
50,000	−56·5	115·9

TABLE II

Height	U.S.A. Pressure	I.C.A.N.
ft.	mb.	mb.
10,000	696·9	696·9
20,000	465·6	465·4
30,000	300·72	300·8
40,000	187·6	187·4
50,000	116·3	115·9

The I.C.A.N. altimeter.—The Mark XIV type of altimeter constructed with the I.C.A.N. atmosphere as standard is shown in the photograph facing p.24. With this type of altimeter the pressure at the level above which it is desired to measure height is set on the instrument by turning the knob at the foot of the dial until the required pressure is seen in the small opening immediately above the knob. This pressure scale, graduated in millibars*, is known as the pressure subscale.

On some types of Mark XIV altimeter pressure can be set within the range 1050 to 800 mb. and on others within the range 1050 to 940 mb.

The height is shown on the circular dial which is graduated from 0 to 10 with each unit subdivided into five subunits. The height is shown by three interconnected hands which rotate clockwise over the dial, the largest hand indicating hundreds of feet, the middle one thousands, and the smallest tens of thousands. The subunits are each of value 20 ft. relative to the largest hand, and the altimeter is sufficiently sensitive to changes in pressure to respond to a change of 10 ft. in height.

The height indicated at any pressure applied to the aneroid capsule is, except for mechanical error, equal to the height interval in the I.C.A.N. atmosphere

* inches in the case of American altimeters.

between the levels at which pressure is subscale pressure and pressure applied to the capsule. The pressure applied to the aneroid capsule of an aircraft in motion differs to a small extent from the static air pressure. The difference is known as position error. It varies with the type of aircraft, and can be allowed for.

The formula for the indicated height is, from equation (1) and because of the principle just stated,

$$H_i = \frac{288}{1 \cdot 98}\left\{\left(\frac{P_G}{P_0}\right)^{0 \cdot 1903} - \left(\frac{P_H}{P_0}\right)^{0 \cdot 1903}\right\} \quad .. \quad (3)$$

where H_i = indicated height in thousands of feet,

P_G = pressure shown on subscale, referred to hereafter as ground pressure.

P_H = pressure applied to aneroid capsule.

P_0 = 1013·2 mb.

Values of H_i for given values of P_G and P_H are readily obtained from a table of heights in the I.C.A.N. atmosphere. For example, if the subscale is set to 977 mb. then at a pressure of 942 mb. the altimeter will read 1,000 ft.

Setting the altimeter for landing.—In landing an aircraft it is desirable that when the aircraft touches down the altimeter should read either zero or the height of the airfield above sea level.

The altimeter can be made to read zero on landing by setting the pressure subscale to the pressure at airfield level which is signalled to the pilot. This pressure is termed QFE in the aircraft signalling code. If the pressure is too low to come in the range of subscale setting pressure this cannot be done, but with an altimeter which can be set down to 800 mb. this is only likely to happen at airfields higher than 5,000 ft. above M.S.L.

If it is desired to make the altimeter read on landing the height of the airfield above M.S.L. the subscale must be set to the pressure at the height in the I.C.A.N. atmosphere found by deducting the height of the airfield from that height in the I.C.A.N. atmosphere at which pressure equals airfield pressure. Thus, if the pressure at an airfield 1,000 ft. above M.S.L. is 942 mb. then the required pressure is the pressure at 1,000 ft. in the I.C.A.N. atmosphere since to 942 mb. corresponds 2,000 ft. The required pressure is thus 977 mb.

American terms for this pressure are " altimeter setting " and " Kollsman number ". The Q-code letters for it are QNH.

At low levels this pressure differs little from the pressure reduced to M.S.L. in the standard meteorological manner, but the difference can amount to a millibar in the case of airfields at 500 ft. and over 2 mb. for an airfield at 1,000 ft.

Table III gives an indication of the differences to be expected between altimeter setting and pressure reduced to M.S.L.

A procedure which can be used if the pressure at airfield level is outside the subscale setting range is to set the subscale to 1013 mb. so that the altimeter reads on landing the height in the I.C.A.N. atmosphere at which the pressure is the airfield pressure. This height, called QFE ALT, QNE in the Q code, is signalled to the pilot.

Setting the altimeter in normal flight, errors of the altimeter.—Normally, for the purpose of avoiding obstacles such as mountain tops it is desirable for the altimeter to read as near as reasonably possible to the true

height above M.S.L. This purpose is roughly achieved by setting the subscale to the pressure at mean sea level at appropriate intervals during flight.

It is therefore necessary to consider the magnitude of the errors in the indicated height which are likely to occur owing to the real atmosphere differing from the I.C.A.N. atmosphere. If the subscale is set to the correct sea-level pressure directly below the aircraft the altimeter can only read correctly if the harmonic mean temperature equals the harmonic mean temperature between the same pressures in the I.C.A.N. atmosphere. Since the indicated height is proportional to the harmonic mean absolute temperature in the I.C.A.N. atmosphere and the true height to the actual harmonic mean absolute temperature it follows that the percentage error of the indicated height equals the percentage difference in the harmonic mean temperatures.

TABLE III

Airfield conditions			Pressure reduced to M.S.L.	Altimeter setting
Height	Pressure	Temperature		
ft.	mb.	° F.	mb.	mb.
200	950	30	957·4	957
		60	956·8	957
		90	956·5	957
	1000	30	1007·7	1007·3
		60	1007·2	1007·3
		90	1006·8	1007·3
500	950	30	968·3	967·5
		60	967·2	967·5
		90	966·2	967·5
	1000	30	1019·3	1018·3
		60	1018·2	1018·3
		90	1017·2	1018·3
1000	950	30	987·1	985·3
		60	984·9	985·3
		90	982·9	985·3
	1000	30	1039·0	1036·8
		60	1036·7	1036·8
		90	1034·6	1036·8

If the I.C.A.N. harmonic mean temperature exceeds the actual value the altimeter will read too high and conversely.

The error can be estimated from the following table of the I.C.A.N. harmonic mean temperatures between 1013 and 300 mb.

TABLE IV—I.C.A.N. HARMONIC MEAN TEMPERATURE 1013 MB. TO *P* MB.

P (in mb.)	900	800	700	600	500	400	300
Harmonic mean temperature (in ° K.) ..	284·8	281·6	278·2	274·1	269·5	264	257

Thus the error in height at 30,000 ft. measured from a pressure of 1013 mb. due to actual harmonic mean temperature differing by 1° from the I.C.A.N. value is 30,000/257 = 117 ft.

The errors in indicated height due to deviation of the actual atmosphere from the I.C.A.N. standard have been worked out for four specimen atmospheres. These will be discussed in Part II. The error due to deviation of the actual atmosphere from the I.C.A.N. can be greatly minimised by the use of the height and air speed computor.

Finally, there is the error due to the variation of gravity with height and latitude. The formula for this is:

$$g = 980{\cdot}62(1 - 0{\cdot}00259 \cos 2\phi)(1 - 2H/E) \qquad \text{.. (4)}$$

where H is the height, ϕ the latitude and E is radius of the earth.

We write this expression as

$$g = g_0(1 - a - bH).$$

Since
$$\int_P^{P_0} \frac{dP}{P} = \frac{1}{R}\int_0^H \frac{g\,dz}{T_0 - lz}$$

where H is the true height of the level of pressure P above the level of pressure P_0 and temperature T_0 in an atmosphere having I.C.A.N. lapse rate but in which g has its true value which is a function of height, then also

$$\int_P^{P_0} \frac{dP}{P} = \frac{1}{R}\int_0^{H_i} \frac{g_0\,dz}{T_0 - lz}$$

where H_i is the height indicated by an altimeter conforming to the I.C.A.N. law in which gravity has the constant value g_0.

Therefore
$$\int_0^H \frac{1 - a - bz}{T_0 - lz}\,dz = \int_0^{H_i} \frac{dz}{T_0 - lz}.$$

Writing $H_i = H + \delta H$, we have

$$\int_0^H \frac{1 - a - bz}{T_0 - lz}\,dz = \frac{\delta H}{T_0 - lH} + \int_0^H \frac{dz}{T_0 - lz}.$$

Hence
$$\frac{\delta H}{T_0 - lH} = -\frac{1}{l}\left(a + \frac{bT_0}{l}\right)\log_e\left(\frac{T_0}{T_0 - lH}\right) + \frac{bH}{l},$$

from which the proportionate error $\delta H/H$ is given by

$$\frac{\delta H}{H} = -a - \frac{bH}{2} + \text{smaller quantities.} \qquad \text{.. (5)}$$

In appropriate units $b = 2/E$ while a has a maximum of 0·0026 at the equator. Thus at a height of five miles above the equator the percentage error is $-0{\cdot}26 - 0{\cdot}125 = -0{\cdot}39$ giving an actual error of $-0{\cdot}02$ miles $= -106$ ft.

At lower heights and other latitudes, the percentage error will be less. The gravity error δH for any particular height H and latitude can be found from the formula:

$$\frac{H}{H} = -\left(a + \frac{bH}{2}\right) \qquad \text{.. (6)}$$

where $a = 0{\cdot}0026 \cos 2\phi$ and $b = 2/E$, where ϕ is the latitude and E is the radius of the earth.

(*To be continued.*)

AGRICULTURAL METEOROLOGY SECTION OF THE CLIMATOLOGICAL BRANCH

BY L. G. CAMERON, M.SC.

It is in the nature of things that the Meteorological Office—the Central Forecasting Office and the Climatological Branch in particular—should have been to some extent associated with farming and its weather or climate problems since its early years. The office first became really "agriculture-conscious" however, in 1924 when, at the instigation of the late Sir Napier Shaw, the "crop-weather scheme" was initiated. This scheme has resulted in the collection of a mass of meteorological observations which have slightly more bearing on agricultural meteorology than those made at ordinary climatological stations and also in some useful studies of such subjects as frost, but temperatures and humidities are still recorded in Stevenson screens and very little has been done to obtain records at crop level.

By May 1944 the Meteorological Office, aided and, to some extent, prompted by Prof. Sir Edward Salisbury, was seriously considering the question of assistance to agriculture and Prof. Salisbury's "Meteorological requirements of the agriculturalist" was quickly followed by M.R.P.198, a report of the work of the Office in relation to agricultural meteorology. An Agricultural Research Sub-Committee of the Meteorological Research Committee was then formed and a programme of subjects for investigation drawn up.

Early in 1946 the first step was taken with the establishment of a meteorological officer at Cambridge where, working in conjunction with the School of Agriculture he began the first of those investigations which were obviously so necessary. Then the problem of establishing a worth-while and permanent contact with agriculturalists was solved by the attachment of an officer as meteorological adviser to the National Agricultural Advisory Service (N.A.A.S.), at the South-West Province Headquarters at Bristol. Finally, a Headquarters Section was formed at Harrow to handle all agricultural climatological inquiries, conduct research into the climatological aspects of British agriculture, satisfy the requirements of meteorological officers attached to agricultural organizations and generally foster the study of agricultural meteorology in all its aspects.

The problems presented by the study of agricultural meteorology need in most cases an entirely new method of approach. The agricultural meteorologist's world is bounded by the depth of the deepest roots and the tops of the highest trees. In actual practice however this is frequently narrowed down to a layer two or three feet in thickness, for within that layer much of the world's supplies of foods and vegetable raw materials and the pests which attack them live and grow. We have in limited numbers soil temperatures down to 4 ft., but long-period information of conditions within the lowest 2–3 ft. of the earth's atmosphere, apart from grass-minimum temperatures and some scanty evaporation data, simply does not exist. So we are faced not merely with a lack of precise information of conditions in the region which concerns us most but also with the fact that this same region also happens to be the atmospheric layer in which the most fundamental variations of temperature, humidity and wind occur. Screen temperature and humidity data, of which there are a superabundance, bear little or no relation to conditions two inches above the ground, whilst to compare directly, the wind at anemometer level with the movement

of air at 1 ft. through a wheat field or orchard would be ludicrous. This problem of relevant data, has not been solved and can never approach a solution unless we superimpose upon the present system of standard climatological observations a series of agricultural meteorological observations specifically designed to satisfy the special requirements of the subject.

The question of forecasting comes next to one's mind. This is the branch of meteorology in which the farmer has been best served for many years. He can, and could even before this last war, avail himself of the general forecast facilities either as a member of the public or by taking advantage of the scheme whereby, for a small sum, he can register his requirements with the Forecast Branch and receive forecasts giving special attention to whatever farming operation, such as harvesting, sowing or spraying, he has in mind. In addition, of course, there are the broadcast forecasts and frost warnings on which he has learned to place a certain reliance. In spite of this there is room for a good deal of improvement on both sides. For our part it is desirable that the country be divided into smaller forecast regions thus making it possible for separate consideration to be given, for instance, to the requirements of the horticultural district of south-west Cornwall and those of the apple-orchards region of Devon. In effect it means of course that local climates be given the full weight of their importance to that patchwork of specialised interests which is British agriculture. From the farmer we ask for the careful perusal of all the information supplied to him, and, since it is not yet possible to cater for every small area and interest, the intelligent application of that information, in the light of his own local knowledge, to his own small part of the country.

Direct contact with the specialists of the N.A.A.S. was most fruitful and the meteorological officer's work at Bristol very quickly unearthed many agricultural problems on which meteorology has a direct bearing. A few examples may serve to illustrate this fact. The ordinary aphide or greenfly, a nuisance to all keen gardeners, is also a major enemy of seed-potato growers and can, given free rein, completely ruin a year's crop. It appears that this insect is the carrier of a virus which when transmitted to the potato haulm causes potato leaf roll and other virus diseases some of which affect the potato itself only in the year after the initial contact. Obviously if the potato industry is to be safeguarded then aphide movement must either be controlled or areas found where its activity is restricted. Now, the aphide's flight is influenced by certain meteorological factors of which temperatures of less than 65° F., relative humidities of more than 70 per cent. and wind speeds greater than 5 m.p.h., all at potato-top height, appear to be critical. Here then was one of our first major problems—that of finding areas where the above conditions prevail during the months of aphide activity and so, in effect, locating regions most suited to the growth of seed potatoes. Other problems, embracing practically every branch of agriculture, include the chocolate-spot disease on beans—a temperature, humidity and rainfall question—the testing of milk in commercial laboratories, the artificial drying of hay and grain, the spraying of fruit and other crops, the frosting of orchards and small fruit plantations, the effects of exposure on farm animals, the influence of cow-shed temperatures and other factors on the "solid-not-fat" content of milk, the climate of a greenhouse and innumerable other kindred questions. All have a meteorological background which needs investigating.

The larger problems of local climates and microclimates are not being forgotten. Local climates must be studied to indicate areas most suited to specialised crops, whilst the investigation of microclimates is continually forcing itself upon us, as in the case of the chocolate-spot disease where we cannot hope to make much progress until we know the microclimatic conditions operating between the individual plants and rows of various spacings. Small microclimatic studies in connexion with the drying of hay have been initiated, in the south-west, recently, by the meteorological officer at Bristol.

It is obvious to everyone that progress in agriculture is to some extent dependent upon advancement in meteorology, but experience has shown that the plane of contact between these two sciences is far more extensive than one might expect. The problems of agriculture are legion and agricultural meteorology must accept the responsibility of contributing to their solution.

METEOROLOGICAL RESEARCH COMMITTEE

The 52nd meeting of the Meteorological Research Committee was held on December 4, 1947. At that meeting it was decided to form three sub-committees to deal respectively with questions relating to (*a*) instruments, (*b*) forecasting and (*c*) physical and dynamical matters.

The Secretary read a letter from Prof. Duperier in which the latter expressed the opinion that cosmic-ray data are entirely consistent with some recent analysis of upper air temperatures which indicate a substantial diurnal variation of temperature at heights of the order of 15 Km. It was decided to consider this matter further at the next meeting.

A paper discussing the accuracy of speed corrections to aircraft thermometers was presented by Dr. Frith.

Two papers dealing with radio-sonde observations were read: one compared the GL.IIIB with the S.C.R.658 for wind-measurement purposes, and the other dealt with the relative advantages of radio-sonde and radar methods of determining the heights of significant points.

On the subject of turbulence in the lower atmosphere a tentative proposal for a new way of computing the turbulent transport of particulate matter was put forward.

ROYAL METEOROLOGICAL SOCIETY

At the meeting of the Society, held at 49, Cromwell Road, on December 17, Prof. G. M. B. Dobson, President, in the Chair, a motion was adopted to elect each year an additional Vice-President for Scotland and an additional Vice-President for each Overseas Branch of the Society that is formed. Then the following papers were read:—

J. A. Chalmers—The capture of ions by ice particles

C. T. R. Wilson suggested in 1929 that a factor producing a separation of charge in thunderclouds was preferential capture of ions of one sign by the falling water drops polarised under the influence of the vertical electric field. Whipple and Chalmers worked out the theory mathematically in 1944.

In the present paper, Dr. Chalmers considered the same ideas as applied to ice crystals. He pointed out that, owing to the high dielectric constant, crystals

of ice would become polarised with charges of the same sign, but smaller magnitude, as conducting particles of the same shape would acquire in the same electric field. The essential distinction between water and ice particles is that charges reaching water drops are spread over the whole surface while those reaching a non-conductor such as ice stay where they arrive. The results of his earlier paper on water drops were then derived in a simpler way than in that paper, and the new method applied to find the rate at which a falling spherical piece of ice would accumulate charge by impact with ions.

Flat ice crystals are dealt with in a similar way but in their case there is the complication of overturning which changes the sign of the induced charges leaving the charges accumulated by contact with ions unchanged. After a brief reference to conditions below clouds Dr. Chalmers considered the main problem of the separation of charge within clouds. The argument is based on the mobilities of large and small ions in electric fields approaching the critical sparking value of 10,000 volts/cm. and the general result is that in all cases the Wilson mechanism is unable to provide an electric current sufficient to explain the observed rates of change of the electric field. In particular it is unable to explain the rapid recovery of field after a lightning flash which begins at a time when there is little electric field to produce the necessary initial polarization.

Dr. Chalmers illustrated his lecture with tennis and ping-pong balls and a piece of card representing hailstones, ions and ice crystals respectively, suitably coloured to indicate the sign of charge.

In the discussion, Dr. F. J. Scrase said the results of the paper would be of value in connexion with the modern theory of the formation of rain, and suggested that radar methods might throw light on the electrical structure as well as the physical structure of clouds.

Dr. T. Wormell, asking whether ice crystals really are perfect non-conductors, said only a small degree of conductivity was needed to make the crystals behave as conductors so permitting the rapid dispersion over the crystal of ionic charges picked up. He also thought the spherical hailstones were unlikely to fall for any distance without turning over since the charge distribution on them was such as to produce an electric couple tending to invert the drop if there were the least displacement from the position of equilibrium.

Dr. Scrase said he thought radar reflections from clouds definitely showed ice crystals to be non-conductors.

R. C. Rainey—Observations on the structure of convection currents: meteorological aspects of some South African gliding flights

In the absence of the author a summary of this paper was given by Mr. F. K. Miles. The paper was concerned with the data obtained during the South African Gliding Contest held near Pretoria in October 1938. First, the paper showed that the maximum height reached by gliders agreed closely with the height of the point of intersection on the tephigram of the dry adiabatic line through the observed screen temperature with the environment curve measured by a nearby aircraft sounding. Three graphic examples were given.

Secondly, the experiences of gliders in the forced flow of air over a steep ridge were used to show a high correlation between the heights reached and the component of wind perpendicular to the ridge.

Thirdly, the ascending and descending currents of air encountered by gliders during long flights on days of convection gave a picture of convective cells of horizontal extent about twice their depth, and of about two miles length downwind, providing an approximate value of the masses of ascending and descending air within a given isobaric slice.

Finally, the author showed examples of flights made in the warm air ahead of a well marked cold front, which gave very much stronger rising currents than could be produced by forced ascent due to undercutting of the warm air by the front and which could only be accounted for as convection currents connected with instability in the unstable warm air concentrated into a narrow zone just ahead of the cold front instead of being scattered over a large area. Observed temperatures showed the warm air to be highly unstable.

In the discussion, Dr. Slater said the air near the ground would not rise as a " thermal " until it was 1° C. warmer than the surrounding air and this higher temperature taken along the dry adiabatic led to an appreciably greater height than that obtained from the ordinary screen temperature. This fact might account for the height reached exceeding somewhat on occasion the height found from the recorded ground temperature. He doubted whether calculations of the component of wind up the slope could be made when the general wind was oblique since the air then appears to have a roller-like motion with axis over the crest. On the question of convection cells, he said, glider pilots thought warm air went up in bubbles rather than in the streams favoured by meteorologists, while for the cold-front effects he was inclined to favour Lange's view that convection ahead of cold fronts was associated with diffusion of cold air above warm air rather than instability in the warm air itself.

Mr. H. H. Lamb agreed that undercutting by cold air could not produce appreciable rising currents by itself, mentioning that in the course of long experience in the construction of vertical sections he had found the maximum slope of a cold front was 1/17. He also asked what allowance was made for the pilot's skill in assessing the height reached in relation to turbulence.

Mr. Gold said he was puzzled by the absence of any reference to water vapour, pointing out that on the first occasion shown in the tephigrams the surface air would, after reaching the condensation level, have gone up in cloud along the saturated adiabatic to a much greater height.

Mr. Miles, in reply, said it was reasonable to assume that the heights referred to were reached by a skilful pilot able to keep the glider in the thermal so long as it lasted. He agreed with Mr. Gold that the effects of water vapour ought to have been considered.

R. W. Hatcher and J. S. Sawyer—Sea-breeze structure with particular reference to temperature and water-vapour gradients and associated radio ducts

Mr. Sawyer, in presenting this paper, gave a brief but clear description of results which had been obtained from special aircraft observations, to examine as closely as possible the temperature and humidity structure of sea-breeze conditions when anomalous radio propagation was likely, made by Hurricanes of No. 1302 Met. Flight, based at Madras on the east coast of India, in April and May 1945. Each set of observations was made by a single aircraft, and the time taken varied from 15 minutes to just over one hour.

The conditions necessary for the formation of a radio duct, or region of super-refraction of radio waves, were either a steep inversion or a steep lapse of water vapour density. The observations (taken on occasions during the afternoon when the sea breeze would be likely to be at its greatest development at intervals varying from three to ten miles horizontally and 200 to 1,000 ft. vertically) showed fairly conclusively that the temperature inversion was not steep enough to form a radio duct, whereas the lapse of water vapour density was more than sufficient. Mr. Sawyer then showed some idealised cross-sections (based on the observations at Madras when there was an upper wind over the sea breeze from land to sea) of typical distributions of potential temperature and water vapour density and of the probable forms of radio duct and stream-lines during the sea breeze.

The investigation provided evidence of the surface radio duct but not of the elevated duct which had been suggested by Dr. Booker; it also suggested the existence of marked turbulence over the coast and only slight subsidence in at least the first 20 miles over the sea.

In the discussion, Dr. Robinson drew attention to Fig. 3 (*b*) in which he pointed out that if the curve showing variation of water-vapour content had been drawn without smoothing there would have been a possible elevated radio duct just below 2,000 ft. A glider pilot present, Mr. L. Welch, mentioned an experience he had had when gliding near Weymouth: he found an upcurrent some few miles off the coast which he had not expected and was in some doubt as to whether to glide further out to sea in the hope of finding it stronger or to come inland again.

In reply, Mr. Sawyer doubted whether the 200-ft. thickness of suitable conditions was enough to cause a radio duct; he admitted there was not firm justification for smoothing the curve in Fig. 3 (*b*). He could offer no explanation of the upcurrent off the coast of Weymouth.

LETTER TO THE EDITOR

Unusual condensation trails

The following phenomenon was reported by F/Lt. H. S. Smith on November 29, 1947, to Mr. Ripley, Meteorological Officer of West Malling:—

Whilst carrying out the meteorological ascent over West Malling at 1100 G.M.T. on that day, condensation trails of an unusual type occurred. The aircraft concerned was a Mosquito, and from 400 mb. to the top of the climb (300 mb.) dense persistent trails were formed by the propellers. The condensation trails were most dense near the centre of each trail. The wings immediately behind the propellers were immersed in the trails and clear ice formed slowly on the leading edge, later spreading back over the wings. There was no cloud at these heights and no ice formed on the aircraft except where immersed in the condensation trails. The corrected air temperatures were $-47°$ F. at 400 mb., $-60°$ F. at 350 mb., and $-72°$ F. at 300 mb.

As far as can be ascertained, no other authentic record of this kind of condensation trail exists. Records of condensation-trail formation over a wide range of conditions and with a large variety of aircraft were amassed during the war without this type being recorded. It can therefore be regarded as both interesting and unusual.

The following note on the synoptic situation on November 29, 1947, has been given by Mr. C. K. M. Douglas:—

A damp air mass probably covered south-east England at about 400 mb. (relative humidity 90 per cent. reported at Downham Market) and could be related to a precipitation area further eastward. The centre of an occluded depression was just east of Brussels at the surface, but was displaced westward aloft and gave a poorly defined centre over south-east England in the 400–300 mb. layer. There was a cold unstable layer over south-east England up to 10,000 ft. and above that a stable layer with a considerable increase of wet-bulb potential temperature. The wind was light and indefinite in the region where the condensation trails formed. The air mass was nearly saturated and at the boundary of an old frontal cloud system.

C. J. M. AANENSEN

NOTES AND NEWS

An old method of obtaining water from the air in dry localities

The problem of getting drinking water from the air by means of artificial condensation of water vapour is important especially in areas of steppes and deserts or key points like Gibraltar.

Siebold, a Russian, while working on the slopes of a mountain range near the ancient Crimean town Theodosia*, uncovered the remains of several huge cones of coarse pebbles of similar size built on solid bases. Some primitive clay-made pipelines were also found connected to some derelict wells at Theodosia. Altogether 8,400 segments of pipelines were recovered during the period 1831–3.

Siebold considered this idea of unknown builders to be as clever as it was simple.

The air is cooled by evaporation as it filters through the cones, and is cooled down to its dew point in the lower part. The surfaces of all the pebbles gave a total surface of an immense size so that a cone was able to provide an appreciable amount of water to the well. The idea may be compared to that of a dew pond employed in southern England.

To prove his conclusion, Siebold had built on a pass of the Tepe-oba range in Crimea a single truncated cone 20 ft. high, with a base 60 ft. in diameter and a top 24 ft. in diameter. The building of the cone was finished in 1912 and gave 36 " buckets " of water a day (equivalent to 80 gallons) even on rainless days. It ought to be mentioned that the district of Theodosia is situated in the lee of a mountain range and practically out of depression tracks. Its annual rainfall does not exceed 25 in. a year but owing to the proximity of the Black Sea, the content of moisture in the air is relatively high.

After a time the cement base of Siebold's cone broke and the outbreak of the first world war prevented further experiments.

In 1934 however, the Central Institute for Experimental Hydrometeorology in Moscow called a conference on December 3. Prof. Tugarinov, S. V. Gorbacev, B. A. Apollov, B. P. Orlov, A. V. Voznesenskij and V. V. Danilevskij

* News summary. Wiad. met. hydrogr. Warsaw, 1936, Nos. 7-9, p. 95.

gave a series of lectures on the subject of artificial condensation of water vapour from the air and its importance for national economy and defence.* A permanent Committee was set up to develop Siebold's idea.

At much the same time French authorities, concerned with the problem of water supply to projected trans-Saharan Bus Communication, made experiments on the subject, but the final results are unknown.

The building of an experimental type of similar cone or condenser was started in Poland in 1939 at the Meteorological observatory on Pop Iwan (6,640 ft.), but the outbreak of the second world war prevented its development.

Unfortunately, no details are available of the type of pebbles used. A mixture of pebble and coarse gravel may help in intensifying the whole process. The greatest possible exposure to air currents is undoubtedly important.

W. MIDOWICZ

[This appears to be a case of collection of mist particles rather than of condensation as dew. The following similar cases are of interest in this connexion.

On the Desertas (islands some 12 miles from Madeira), which are streamless and springless, fishermen live by water obtained by spreading out fleeces in the evening, and wringing the dew from them in the morning.†

Marloth exposed two 5-in. rain-gauges on Table Mountain, one in the ordinary way and the other having a number of reeds fixed in such a way that any moisture deposited on them dripped into the gauge. Within two months the first rain-gauge collected 4·9 in. of rain and the second 70·8 in. During the first ten days of this period, whilst the first gauge collected nothing, the second collected 15·2 in.‡

In the island of Ferro (Hierro), in the Canaries, the condensation on the leaves of one special tree (known as the Garoe or Til and situated in the declivity of a hill) used to be collected into two cisterns beneath the tree in such quantities as to supply drinking water from one of the cisterns and water for cattle, washing and such-like purposes from the other.§—C. E. P. BROOKS]

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* Stenogramma Pervoj Konferencii po Kondensacii vodjanych parov voxducha. Moscow, 1935.

† HUBBARD, A. J. and HUBBARD, G.; Neolithic dew ponds and cattle-ways. London, 1907, p. 115.

‡ MARLOTH, –.; Results of experiments on Table Mountain for ascertaining the amount of moisture deposited from the south-east clouds. *Trans. S. Afr. phil. Soc. Cape Town*, **14**, 1903–4, p. 403 and **16**, 1905–7, p. 97.

§ HUTCHINSON, J.; The rain tree of Hierro, Canary Islands. *Kew Bull. London*, No. 3, 1919, p. 153.

Snow rollers

Snow rollers were formed at Full Sutton, Yorks, on January 10, 1945, during a rather prolonged snow shower which lasted from 0830 to 0925 G.M.T. Before the shower commenced the ground was covered by an even layer of snow, 2 to 3 in. deep.

The intensity of the snow was generally slight, though increasing to moderate at times. The surface wind was NW. 5 m.p.h., the air temperature 28·9° F. and the dew point 27·9° F.

The photograph facing p. iii of cover was taken about an hour after the shower ceased, there being no further snow during the interval.

The number of rollers formed was extremely large both on the open space of the airfield and also in the rather more sheltered fields close by.

In shape the rollers were cylindrical and hollow at both ends. They were composed of several layers each being about 2 inches thick. The rollers varied considerably in dimension, the largest being up to 3 ft. long and 1 ft. 6 in. in diameter. Leading to each roller was a trough from which the snow forming the roller had been removed. The trough broadened the nearer it got to the roller, indicating that there was gradual growth both in length and diameter.

The snow was loosely packed and the rollers disintegrated at the slightest rough handling, also when the wind speed increased to 15 m.p.h.

It is interesting to note that in a later snow shower with a wind of 10 m.p.h. and a temperature of 34° F., further rollers were not formed.

Unfortunately the photograph had to be taken in very poor light, 10-tenths thick cloud obscuring the sun. A close-up of a roller was also taken but this photograph proved a failure.

G. BUNTING

REVIEWS

A hőmérséklet szerepe a rovarok életében (Effects of temperature on the life of insects), by G. A. Manninger. *Időjárás, Budapest.* **51**, 1947, pp. 75–8 (English summary, p. 103).

This paper, in the Hungarian meteorological journal, is of special interest to agricultural meteorologists in this country in that it describes work which bears a close relationship with our own recent research on the meteorological aspects of aphide activity.

After dealing with the fact that insects possess only limited means of heat regulation the author proceeds to illustrate this by a curve in which insect activity is plotted as a function of the temperature. He further demonstrates the importance of temperature as a control in insect development by reference to the development of generations of the gallfly of alfalfa buds, and also by a neat graphical illustration of the decline of the European corn-borer (Pyrausta nubilalis Hühn) during the months of June and July, 1945, when temperatures were well below average. His concluding remarks, to the effect that in Hungary owing to its continental climate insect damages to crops are of the utmost importance, can also apply with equal force to this country.

Dr. Manninger's final contention that the practical application of meteorology to these entomological problems promises to open the way to the prevention of insect damage to crops is perhaps somewhat optimistic. At this stage we feel that it would be more prudent to think in terms of a large-scale reduction of insect damage rather than of its complete elimination.

L. G. CAMERON

Polar lights, by C. M. Botley. 8vo. $8\frac{1}{2}$ in. × $5\frac{1}{2}$ in. pp. 31 *Illus*. Obtainable from the author, 2, Park Road, Tunbridge Wells. 1947. Price 3*s*.

This booklet is addressed to those people who regard things animate and inanimate " with an interest which has in it something of affection ". The

author sets out to bring to light some of the knowledge of the aurora polaris which has hitherto remained buried " in the pages of learned journals or ponderous text books ", and on the whole she has succeeded in presenting this knowledge in a very readable form.

The first chapter is a brief historical survey of references to the aurora in such widely different books as the Bible and Shakespeare's " Julius Caesar ", and contains some amusing accounts of ancient beliefs about the aurora and what is portended. More modern descriptions of the aurora and theories about its origin are dealt with in the second chapter. Many memories will be stirred by the accounts of the great displays of March 23, 1946, and more especially January 25, 1938. Such controversial subjects as the possibility of hearing the aurora and of its occurrence in the lower layers of the atmosphere are ably covered. In the last chapter advice is given to those who wish to observe the aurora and keep a scientific record of their observations.

The only illustration is a drawing of a corona seen in Cumberland on April 23, 1946. It is a pity that it was not possible to include a few photographs of the more definite auroral forms. Failing this, reference should have been made in the note on " Further reading " to the excellent " Photographic atlas of auroral forms " published by the International Geodetic and Geophysical Union, which many regard as an indispensable book for anybody making a serious study of the aurora. A brief reference to the recent exciting possibilities of producing artificial aurora (a patent has been taken out to cover the use of artificial aurora as a possible form of street lighting) would also have enhanced the value of this otherwise very fascinating little book.

O. M. ASHFORD

NEWS IN BRIEF

On November 28, 1947, at 7 p.m., Mr. Seton Gordon observed a particularly fine lunar rainbow spanning Nig Bay in the Isle of Skye. Mr. Gordon has frequently seen lunar rainbows, " but never one with an equal brilliance, the colours being almost as clear and striking as those of a solar rainbow ". About 15 minutes later when Mr. Gordon was at a different part of the road, a second lunar rainbow formed of less strength than the first.

WEATHER OF NOVEMBER, 1947

During the greater part of the month pressure was high over the Arctic, especially Greenland, and over Spain or southern Europe. Between these two anticyclones a series of depressions, some of them intense, passed between Scotland and Iceland. On the 3rd pressure fell below 976 mb. between the Faroes and Shetlands, and on the 22nd–23rd below 964 mb. south and east of Iceland. These unsettled conditions were interrupted on 6th–7th and 15th-19th when the two anticyclones united in a ridge of high pressure across Britain, bringing cold spells. The second of these ended abruptly on the 20th when a deep depression in mid Atlantic brought a stream of very mild tropical air over Britain. Cold conditions returned on the 24th when high pressure extended over the Atlantic west of these islands in the rear of a depression over Europe.

The pressure map for the month as a whole shows high-pressure areas exceeding 1025 mb. centred over north-east Greenland and central Spain, separated by a trough below 1005 mb. running east-north-east from 50° N. 30° W. to central Norway. Pressure was 12 mb. above normal over Greenland, Jan

Mayen and Spitsbergen, 7 mb. below normal over the Baltic countries and as much as 15 mb. below normal in mid Atlantic west of the Azores.

Temperatures were generally several degrees above normal in Spain and central Europe but below normal in Scandinavia and Greenland; Oslo, with a mean for the month of 27° F., was 5° F. below normal, and Myggbukta in north-east Greenland (mean: − 7° F.) was 10° F. below normal. Precipitation was generally deficient in Spain and the western Mediterranean but Lisbon had the unusual total of 13 in. compared with a normal of only 5 in.

The weather over the British Isles was distinguished by strikingly large and rapid fluctuations of temperature. The first twelve days were mild and unsettled but cold polar air in the rear of a depression over the Baltic on the 13th was the prelude to a very cold spell. Considerable snow fell in the north of Scotland from the 15th–17th while a secondary depression moving east-south-east from south-west Ireland caused widespread snow and sleet in England and Wales on the 18th. Very low minimum temperatures were recorded locally on the 19th, for example, 1° F. at Dalwhinnie and 3° F. at Braemar. By the 20th, however, tropical air from southward of the Azores in front of a large and complex depression on the north-east Atlantic was drawn in over the British Isles; this air current was excessively mild and humid and temperature rose by 15° to 25° F. or more in 24 hours. There was thus no gradual warming of buildings and water streamed down their inside walls. In the west and north unusually heavy rain also occurred, notably 6·28 in. at Glenquoich, 4·45 in. at Kinlochourn and 4·24 in. at Erracht all in Inverness-shire. The rapid thawing of the snow together with torrential rains caused severe flooding in Lochaber. A few very mild days ensued but on the 24th another influx of cold polar air caused a very rapid fall of temperature and cold showery weather with bright periods persisting until the end of the month.

Mean temperature for the month exceeded the average except in the north of Scotland where it was slightly below the average. Broadly speaking rainfall increased north-westward from less than 50 per cent. of the average in an area extending from south of Cambridge to the Sussex coast and locally in Hampshire to more than 175 per cent. in Snowdonia, the western Pennines, locally in Cumberland and in a fairly large area from the Moray Firth to near the west coast of Scotland. The month was notably sunny in most districts. There was a deficiency, however, in the neighbourhood of the Moray Firth and in parts of Wales and south-west and south England. Widespread fog occurred in England and Wales on the 6th–7th and caused considerable dislocation of traffic.

The general character of the weather is shown by the following table:—

	Air Temperature			Rainfall		Sunshine	
	Highest	Lowest	Difference from average daily mean	Percentage of average	No. of days difference from average	Percentage of average	Percentage of possible duration
	°F.	°F.	°F.	%		%	%
England and Wales	65	14	+2·1	87	−1	126	29
Scotland	63	1	0·0	139	+2	131	28
Northern Ireland ..	62	23	+2·0	153	+3	128	31

RAINFALL OF NOVEMBER 1947

Great Britain and Northern Ireland

County	Station	In.	Per cent of Av.	County	Station	In.	Per cent of Av.
London	Camden Square	1.01	43	*Glam.*	Cardiff, Penylan	4.70	116
Kent	Folkestone, Cherry Gdns.	2.30	71	*Pemb.*	St. Ann's Head	4.77	119
,,	Edenbridge, Falconhurst	1.38	39	*Card.*	Aberystwyth	3.67	99
Sussex	Compton, Compton Ho.	1.95	51	*Radnor*	Bir. W. W., Tyrmynydd	6.84	103
,,	Worthing, Beach Ho. Pk.	1.39	43	*Mont.*	Lake Vyrnwy	9.18	158
Hants.	Ventnor, Roy. Nat. Hos.	2.34	73	*Mer.*	Blaenau Festiniog	20.09	189
,,	Fordingbridge, Oaklands	1.42	42	*Carn.*	Llandudno	4.13	143
,,	Sherborne St. John	1.65	58	*Angl.*	Llanerchymedd	4.51	107
Herts.	Royston, Therfield Rec.	1.17	50	*I. Man.*	Douglas, Boro' Cem.	7.06	150
Bucks.	Slough, Upton	1.19	54	*Wigtown*	Port William, Monreith	6.01	139
Oxford	Oxford, Radcliffe	1.26	55	*Dumf.*	Dumfries, Crichton R.I.	4.70	128
N'hant	Wellingboro', Swanspool	1.41	66	,,	Eskdalemuir Obsy.	8.68	150
Essex	Shoeburyness	.87	41	*Roxb.*	Kelso, Floors	2.87	124
Suffolk	Campsea Ashe, High Ho.	1.48	67	*Peebles.*	Stobo Castle	4.74	143
,,	Lowestoft Sec. School	1.41	60	*Berwick*	Marchmont House	2.66	89
,,	Bury St. Ed., Westley H.	1.46	63	*E. Loth.*	North Berwick Res.	2.29	102
Norfolk	Sandringham Ho. Gdns.	1.45	58	*Midl'n.*	Edinburgh, Blackf'd. H.	2.90	129
Wilts.	Bishops Cannings	1.80	63	*Lanark*	Hamilton W. W., T'nhill	5.61	157
Dorset	Creech Grange	2.74	62	*Ayr*	Colmonell, Knockdolian	6.05	121
,,	Beaminster, East St.	2.35	59	,,	Glen Afton, Ayr San.	8.20	149
Devon	Teignmouth, Den Gdns.	2.12	66	*Bute*	Rothesay, Ardencraig	7.45	147
,,	Cullompton	2.82	82	*Argyll*	Loch Sunart, G'dale	9.63	129
,,	Barnstaple, N. Dev. Ath.	3.27	83	,,	Poltalloch	..	..
,,	Okehampton, Uplands	4.16	78	,,	Inveraray Castle	14.04	166
Cornwall	Bude School House	2.70	76	,,	Islay, Eallabus	8.33	155
,,	Penzance, Morrab Gdns.	3.55	78	,,	Tiree	5.85	121
,,	St. Austell, Trevarna	4.99	101	*Kinross*	Loch Leven Sluice	3.91	109
,,	Scilly, Tresco Abbey	2.96	86	*Fife*	Leuchars Airfield	1.75	76
Glos.	Cirencester	1.83	61	*Perth*	Loch Dhu	12.48	144
Salop	Church Stretton	2.41	78	,,	Crieff, Strathearn Hyd.	4.45	103
,,	Cheswardine Hall	2.20	85	,,	Blair Castle Gardens	4.64	132
Staffs.	Leek, Wall Grange, P.S.	3.73	120	*Angus*	Montrose, Sunnyside	1.98	75
Worcs.	Malvern, Free Library	2.14	85	*Aberd.*	Balmoral Castle Gdns.	3.28	89
Warwick	Birmingham, Edgbaston	1.87	79	,,	Aberdeen Observatory	2.80	94
Leics.	Thornton Reservoir	2.02	89	,,	Fyvie Castle	4.04	117
Lincs.	Boston, Skirbeck	1.09	55	*Moray*	Gordon Castle	5.31	184
,,	Skegness, Marine Gdns.	1.30	60	*Nairn*	Nairn, Achareidh	3.85	171
Notts.	Mansfield, Carr Bank	1.85	76	*Inv's*	Loch Ness, Foyers	8.42	216
Ches.	Bidston Observatory	3.25	130	,,	Glenquoich	21.75	179
Lancs.	Manchester, Whit. Park	3.76	142	,,	Fort William, Teviot	13.98	170
,,	Stonyhurst College	7.67	170	,,	Skye, Duntuilm	8.17	136
,,	Blackpool	3.80	110	*R. & C.*	Ullapool	7.90	153
Yorks.	Wakefield, Clarence Pk.	2.00	94	,,	Applecross Gardens	9.00	139
,,	Hull, Pearson Park	1.43	65	,,	Achnashellach	15.28	177
,,	Felixkirk, Mt. St. John	2.02	82	,,	Stornoway Airfield	7.65	138
,,	York Museum	1.40	67	*Suth.*	Lairg	5.26	132
,,	Scarborough	2.11	85	,,	Loch More, Achfary	14.46	169
,,	Middlesbrough	1.72	81	*Caith.*	Wick Airfield	5.05	161
,,	Baldersdale, Hury Res.	5.27	142	*Shet.*	Lerwick Observatory	5.67	133
Nor'ld	Newcastle, Leazes Pk.	2.51	107	*Ferm.*	Crom Castle	5.27	151
,,	Bellingham, High Green	4.27	124	*Armagh*	Armagh Observatory	4.00	141
,,	Lilburn, Tower Gdns.	3.01	90	*Down*	Seaforde	4.04	107
Cumb.	Geltsdale	4.72	144	*Antrim*	Aldergrove Airfield	3.82	118
,,	Keswick, High Hill	10.11	179	,,	Ballymena, Harryville	6.07	150
,,	Ravenglass, The Grove	5.07	113	*Lon.*	Garvagh, Moneydig	6.58	167
Mon.	Abergavenny, Larchfield	3.45	90	,,	Londonderry, Creggan	8.01	195
Glam.	Ystalyfera, Wern House	8.44	128	*Tyrone*	Omagh, Edenfel	7.47	197

CLIMATOLOGICAL TABLE FOR THE BRITISH COMMONWEALTH, JULY 1947

Stations	Pressure: Mean of day M.S.L.	Pressure: Diff. from normal	Temperatures: Absolute Max.	Temperatures: Absolute Min.	Temperatures: Mean values Max.	Temperatures: Mean values Min.	Temperatures: Mean values ½ Max. and Min.	Temperatures: Mean values Diff. from normal	Temperatures: Mean values Wet bulb	Relative humidity	Mean cloud amount	Precipitation: Total	Precipitation: Diff. from normal	Precipitation: Days	Bright Sunshine: Daily Mean	Bright Sunshine: Percentage of possible
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	tenths	in.	in.		hr.	%
London, Kew Observatory	1015.0	−0.9	85	51	72.7	58.5	65.6	+2.6	60.3	75	8.2	1.41	−0.76	13	4.7	29
Gibraltar	1015.3	−1.5	87	64	83.6	69.6	76.6	+1.8	71.0	79	3.0	0.10	—	2	—	—
Malta	1013.3	−1.4	94	68	87.6	71.7	79.7	+1.4	72.7	58	1.9	0.23	—	2	11.7	82
St. Helena	1019.3	−0.8	64	52	60.6	53.9	57.3	−1.0	54.4	96	9.7	4.18	+0.05	25	—	—
Freetown, Sierra Leone	1014.3	+3.3	88	70	83.0	73.8	78.4	+1.5	75.2	89	8.8	35.69	+0.11	28	3.2	26
Lagos, Nigeria	1013.9	+0.7	86	67	81.6	71.1	76.3	−1.7	74.6	91	9.5	13.66	—	16	1.8	15
Kaduna, Nigeria	1012.1	—	88	64	83.4	68.1	75.7	+1.5	70.9	84	9.1	7.76	−2.86	20	5.4	43
Chileka, Nyasaland																
Salisbury, Rhodesia																
Cape Town	1021.0	−0.3	74	39	60.9	47.7	54.3	−0.4	49.0	85	6.7	7.71	+4.09	20	—	—
Germiston, South Africa	1024.5	—	69	24	60.2	33.5	46.9	—	36.1	42	1.9	0.06	—	4	9.4	89
Mauritius																
Calcutta, Alipore Obsy.	998.1	−0.8	95	78	90.1	79.7	84.9	+1.2	79.9	88	8.8	16.04	+3.34	27	3.7	28
Bombay	1003.1	−0.8	92	72	86.8	77.6	82.2	+0.8	78.2	87	9.3	22.03	−2.24	31	—	—
Madras	1004.2	−0.3	99	71	94.9	79.2	87.1	−0.5	75.4	70	8.9	4.74	+0.90	9	3.9	30
Colombo, Ceylon	1009.1	0.0	88	74	86.1	77.1	81.6	+0.4	76.6	84	7.6	7.06	+2.63	19	6.4	51
Singapore	1008.9	0.0	93	73	87.9	74.6	81.3	0.0	78.1	82	—	5.04	−1.75	10	—	—
Hongkong	1006.0	+1.3	90	74	87.1	77.8	82.5	0.0	78.8	88	—	22.82	+8.40	25	5.3	40
Sydney, N.S.W.	1016.5	−1.8	71	39	62.8	46.1	54.5	+1.8	46.5	68	3.2	0.55	−4.25	8	7.3	71
Melbourne	1014.7	−4.2	62	37	56.2	44.8	50.5	+1.8	45.8	76	7.4	3.71	+1.85	19	2.7	28
Adelaide	1017.6	−2.6	64	38	58.2	46.0	52.1	+0.2	47.1	76	8.3	2.99	+0.35	20	3.1	31
Perth, W. Australia	1018.0	−1.0	70	40	63.4	48.8	56.1	+0.9	52.2	72	6.0	6.73	+0.17	24	5.2	51
Coolgardie	1018.7	−1.2	77	35	61.0	41.3	51.1	−0.1	44.6	79	4.2	1.54	+0.67	10	—	—
Brisbane	1019.1	+0.7	75	40	70.1	46.4	58.3	−0.2	50.4	54	2.2	0.34	−1.86	1	8.6	81
Hobart, Tasmania	1010.0	−3.7	58	33	52.7	40.0	46.3	+0.6	41.3	77	6.6	2.80	+0.62	16	4.9	52
Wellington, N.Z.	1015.2	+1.3	60	32	52.8	41.7	47.3	+0.9	44.1	85	6.4	2.94	−2.69	18	4.4	46
Suva, Fiji	1014.0	0.0	85	63	78.7	69.7	74.2	+0.8	71.0	85	8.1	7.31	+2.38	18	3.0	27
Apia, Samoa	1012.0	+0.1	89	70	86.3	74.4	80.3	+3.1	76.5	80	4.9	8.35	+5.37	23	7.6	67
Kingston, Jamaica	1014.7	0.0	95	74	91.5	76.1	83.8	+2.1	75.7	64	4.8	3.62	+2.00	6	8.1	62
Grenada, W. Indies	1014.1	+0.8	86	73	84.9	76.8	80.9	+1.7	77.0	81	7.9	8.22	−1.21	28	—	—
Toronto	1016.3	+1.9	90	50	78.5	61.0	69.7	+0.6	61.5	78	6.0	5.64	+2.80	13	7.2	48
Winnipeg	1013.3	+1.0	93	43	81.7	58.1	69.9	+3.5	59.2	86	5.9	2.94	−0.16	7	10.4	65
St. John, N.B.	1014.8	+1.2	80	52	68.7	56.3	62.5	+2.1	59.4	98	8.9	2.09	−1.54	15	4.0	26
Victoria, B.C.	1016.6	−0.7	83	43	72.2	51.0	61.6	+1.5	51.8	87	5.5	0.91	+0.49	8	10.2	65

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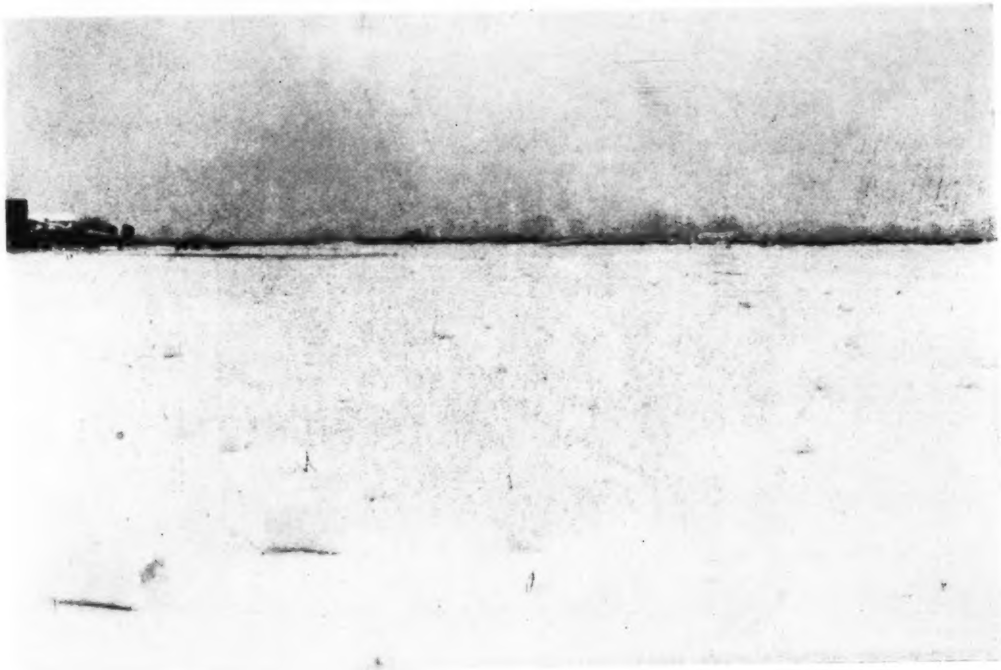
MARK XIV ALTIMETER

(see p. 8)



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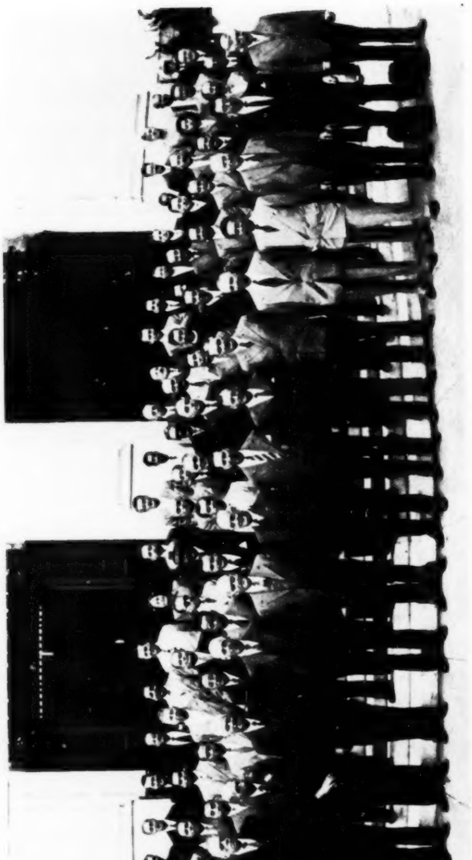
SNOW ROLLERS AT FULL SUTTON, YORKSHIRE, JANUARY 10, 1945

(see p. 19)

Frontispiece]



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SEPTEMBER 22 TO OCTOBER 11, 1947